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SOME DATA ABOUT FIRE-FIGHTING FACILITIES AT METAL MINES IN THE UNITED STATES

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DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

SOME DATA ABOUT FIRE-FIGHTING FACILITIES AT METAL MINES IN THE UNITED STATES[1]

By D. O. Kennedy[2]

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INTRODUCTION

During the recent war attention was directed to prevent the destruction of American industries by sabotage. By Executive order of May 19, 1942, the Bureau of Mines was required to conduct investigations and make recommendations that would prevent loss of production of essential war minerals. The Health and Safety Branch of the Bureau of Mines was able to extend its activities with minimum loss of time to include security surveys of the important mineral facilities in the United States.

A Mineral Production Security Division was established in the Health and Safety Branch with funds appropriated for that purpose by Congress in April 1942. From July 1942 to July 1945 engineers of this division, under the direction of D. Harrington, Chief, Health and Safety Branch, and J. J. Forbes, Chief, Mineral Production and Security Division, conducted investigations of 1,560 metallic and nonmetallic mines and associated facilities in accordance with the requirements of the Executive order.

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[1] The Bureau of Mines will welcome reprinting of the paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7374."

[2] Mining engineer, Safety Division, Bureau of Mines, Washington, D. C.

PURPOSE

An analysis of losses in the production of minerals shows that failure or destruction of equipment either from deliberate or accidental causes produces essentially the same result. Maximum production is insured by the prevention of subversive activities, fires, and industrial accidents.

A study of the reports made by the Mineral Production and Security Division emphasizes the importance of the four fundamentals in the prevention and control of fire losses[3] - safe construction, safe operation, protective equipment, and an organization to handle emergencies. This paper summarizes information about fire hazards encountered in the mineral industry. It is hoped that the information may be helpful to the industry in the prevention of fires in time of peace, although the information was obtained from reports made in time of war.

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OBSERVED FIRE-PREVENTIVE MEASURES

Smelters and Refineries

Fire-preventive measures at mines and associated facilities have a close relationship to the size and nature of the work.

Smelters and refineries usually are permanent installations and do not depend on one or two mines of limited life for their supply of ore. Continuous operations must be maintained for economical reason, furnaces must be kept at a high temperature, charges must be added, and products must be drawn in regular sequence, or the furnaces may be ruined. Many smelters depend on the successful recovery of small quantities of precious metals in the ore, and any interference with established procedure may result in metallurgical losses affecting the financial stability of the company.

The necessity for fire prevention ordinarily is recognized at such plants, and careful attention is given to suitable construction of buildings and to the isolation of hazardous operations. An adequate water supply is provided,

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[3] F. L. Ahern, Chief, Safety Division, National Park Service, U. S. Department of the Interior; memorandum to J. J. Forbes, Nov. 19, 1943.

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large water mains are installed as fire lines, and sprinkler systems are placed in the buildings that are used infrequently or intermittently. Miscellaneous first-aid fire-fighting equipment usually is found where fires may originate. Employees are generally trained in fire-fighting methods, and practice fire drills are conducted with careful attention by those responsible for fire protection. The trained crews and equipment at many smelters and refineries can be compared favorably with municipal fire departments.

Large Mines

A few of the largest mines with substantial reserves of ore are as well-protected as efficiently equipped and operated smelters. Surface buildings are constructed of incombustible materials, stocks of combustible supplies are isolated, and careful attention is given to means designed to prevent a fire from spreading from one area to another. In some of these mines concrete and steel are used underground in place of combustible timbers, and electric equipment is maintained in excellent condition. Many mines have mechanical ventilation which, when suitably installed and maintained, insures control of air currents under adverse conditions. Fire-fighting equipment usually is provided on the surface and in the mine. Some men on each shift are trained in fire-fighting methods, and practice fire drills are held at frequent intervals.

Of the facilities investigated less than 6 percent employed over 500 men, and more than 54 percent employed fewer than 50 men. In the group that employed between 50 and 500 men, conditions were found ranging from very good to extremely poor. However, many of the larger mines in this group have excellent fire-preventive measures on the surface but have done practically nothing underground. The amount of combustible material in the mine is often thought to be of little value compared to the investment for surface buildings and machinery. In many cases, a few doors installed to prevent the circulation of smoke through the mine workings are thought to provide adequate protection for human life. Many plants had provided fire-fighting equipment but in the past years have forgotten that many of the old hazards and probably numerous new ones exist. Fire-fighting equipment was allowed to deteriorate and fire lines were found to be unserviceable from rust and disuse. First-aid fire-fighting equipment is of great value in time of need, but after years without use its relative importance decreases. Often when room is needed for the expansion of other activities, the little-used fire-protection equipment is moved from one place to another until it becomes hidden, lost, or forgotten.

Small Mines

Fire losses are assumed to be unimportant at small mines and their milling plants. The operation of such mines often is undertaken with insufficient capital to acquire even the desirable type of operating machinery in the mine or in the mill, and little or no money is available for such "fads" as fire prevention or protection. The construction of buildings at small plants usually is not planned with thought of preventing fires or of handling them if they should occur but of providing the minimum necessary protection from exposure to weather. Adits and shafts have coverings erected by cold workmen with whatever material can be procured. In winter, protection from the cold weather becomes necessary, but protection from fire remains a remote future possibility.

Fire-fighting equipment rarely can be used to increase the daily output of any mine; if considered at all, it is included among the future improvements to be undertaken when the financial status of the mine is assured. Flimsy, temporary structures frequently are enlarged by equally unsatisfactory additions, and expenditures for precautionary provisions such as second entrances to mines or means to prevent smoke from outside entering the mines are considered unnecessary and often impossible.

Air lines and possibly water lines are installed in the active workings of the mine to conduct normal mining operations. These can be utilized for fighting fires provided some necessary provisions have been made to allow for such use. However, in many mines, especially the small ones, little if any thought is given to controlling air currents as long as work can be conducted without very much loss in efficiency.

The number of metal mines that become large producers is relatively small, and many small mines operate for years with little or no improvement of fire-prevention methods or fire-protection facilities. Many mines cannot operate continuously because they depend on fluctuating metal prices, and during the war bonuses and better metal prices permitted many marginal mines to be reopened. The small-mine operator is usually an optimist and invests everything he has or can borrow in the belief that his mine will improve; the possibility of a fire too often is thought to be just another element of chance over which he has little control.

Fire-insurance companies have emphasized the need for adequate fire protection and have provided inspection and advisory service for policy holders. The excellent condition of fire protection at smelters and a few large mines is due largely to the efficiency of the field representatives of insurance companies. Insurance rates reflect the general condition of the plant, and many items such as type of construction, location and kind of occupancy of buildings, types of fire-fighting equipment, and service of the watchmen are considered in determining the class of fire risk. Where the fire risk is great the rates are likely to be high, and every means taken to reduce the fire risk helps to reduce the rate. The smaller mines that give little or no thought to fire prevention usually pay extremely high rates or remain uninsured.

RECOMMENDED FIRE-PREVENTIVE MEASURES

Surface

One of the important duties of Bureau of Mines engineers engaged in accident-prevention work is to teach fire prevention. Much can be accomplished by making fire prevention an essential part of every construction program.

In many instances it is not feasible to rebuild poorly erected structures, but when additions or new installations are required, conditions can be improved. If the structures are built of wood or other combustible material, chimneys or hot exhaust pipes should be well-insulated. Wherever possible, buildings should be separated to delay the spread of fire from one building to another, and the doors should be placed so that hot gases or smoke from one building will not enter another building.

The storage of oil and grease is given little or no consideration at many mines. It usually is difficult to convince the operator of a small property that it is advantageous to store oil and grease in an isolated building, as he knows that the total amount stored at his property is sometimes less than that used daily at larger mines. One of the simplest methods of preventing the rapid spread of fire is to keep the amount of combustible material at a minimum. The storage of oil and grease in an isolated building and the removal, at frequent intervals, of waste materials are good housekeeping practices that all mines, including small mines, can adopt with little or no additional expense and often with definite decrease of expense.

Gasoline, when used to clean machine parts in repair shops, presents a constant fire hazard, which can be removed by the use of a readily available nonflammable cleaning solution.

Where combustible materials are present - and nearly all metal mines have combustible materials, such as timber, explosives, flexible ventilation tubing, etc. - every effort should be made to prevent the introduction of unnecessary sources of ignition. "No smoking" signs should be posted to remind employees of the fire hazards, and the "no-smoking" rule should be enforced.

Welding and cutting operations are accompanied by ignition hazards, which can be controlled if reasonable care is exercised. These operations have started numerous fires, especially in timbered shafts.

Open fires in forges should be attended at all times, and special care should be taken to extinguish them completely before the attendant leaves. Warming or softening oils or greases on or near open fires in forges is decidedly dangerous.

Electric wires should be maintained in good conditions; fuses having suitable electric capacity should be inserted and maintained for safety in each electrical circuit; extension cords should be restricted to use in temporary work, kept in good repair, and removed when not in use. Switches should be provided in each circuit so that lines not in service can be deenergized and lines not in use should be kept deenergized insofar as feasible.

Many of the hazards of unsafe construction can be moderated by extra precautions in operation, and the size and rapidity of spread of a fire may be limited to the extent that such precautions are observed.

Underground

The foregoing precautions can be applied underground with equal effectiveness. Sawdust, scrap wood, and old timbers should not be allowed to accumulate but should be taken out of the mine. These materials are often piled in unused crosscuts, each pile presenting an unnecessary fire hazard. Smoking should be prohibited in heavily timbered places in a mine, electric wires should be removed from such places wherever possible, and such wires as are necessary should be well-insulated and protected from wear. The use of electric cap lamps throughout the mine instead of carbide lamps is an efficient means of removing a source of ignition. Many competent safety engineers experienced in matters pertaining to fires in metal mines believe that smoking should be prohibited in all metal mines.

Operators of oxyacetylene equipment should be fire-conscious, and emergency repair work should be done with careful regard to the materials present. This is of especial importance in or near the vicinity of timbered shafts, stopes, raises, or winzes.

The possibility of destroying large quantities of expensive equipment or large reserves of ore may be slight in many mines; as a result, the danger to human life is forgotten; however, a small fire underground may cause more fatalities than a large conflagration on the surface. Loss of life caused by underground fires has been greatest from suffocation and asphyxiation. The products of combustion are not dissipated as in surface fires but may be carried by the ventilating currents through manways and working places. It is important to remember that mine fires almost always cause their own moving air currents. Fire doors are installed to prevent the circulation of smoke throughout some mines, but in many instances they have been left open because of thoughtlessness or panic on the part of employees, have been rendered inoperative by dirt or rock piles, or have been destroyed by unexpected explosions. The removal, where feasible, or the isolation of combustible materials with removal of ignition agencies is the safest method by which disastrous mine fires can be prevented.

WATER SUPPLY FOR FIRE FIGHTING

One well recognized axiom of fire fighters is that an adequate supply of water be provided and kep readily available. Where a source of water is easily available, the daily consumption of water usually is the limiting factor on the size of pipe lines installed. If a large quantity of water is required for operating purposes, large-diameter pipe lines are found, and an adequate supply of water is to be had throughout the plant. However, where only a small amount is required, small-diameter pipe lines are provided, and the amount necessary for ordinary purposes is assumed to be ample for fire-fighting needs. The theoretical amount of water that can be forced through a pipe line is of little interest to the average mine operator. If more water is needed for drilling or milling, a pipe line with a larger diameter is provided, and the work continues. The same practical rules should apply to pipe lines used for fire protection. Usually the need for a large-diameter pipe line is not apparent until it is found that a fire cannot be brought under control, then the pipe line cannot be installed in time to save the property.

A fire stream to be effective uses approximately 250 gallons of water per minute, and usually standard-size fire hose and large mains are necessary to carry this amount. The average mine operator does not believe it possible to provide such equipment and prefers to rely on a municipal fire department. Reliance upon municipal fire departments may be satisfactory for mines close to them, but too often unavoidable delays in arriving at isolated mines nullify the effectiveness of equipment of the fire department.

In arid parts of the country, an adequate supply of water is a major problem and small mines are often unable to supply enough water for drinking and for drilling. In many cases the capital investment in surface buildings would not justify an expenditure of the amount of money necessary to provide a supply of water for fighting fire. Under these conditions it was found that many operators felt nothing could be done, and no provisions were made for fighting fires.

FIRST-AID FIRE-FIGHTING EQUIPMENT

Most surface and underground fires have small beginnings and small fires not extinguished promptly may gain headway with astonishing rapidity.

First-aid fire-fighting equipment, such as portable extinguishers, has definite limitations but is effective on fires when the amount of liquid or gas in the extinguisher is enough to cool or blanket the burning material. Extinguishers are made in many sizes, and arguments are advanced in defense of each size; small, dry-compound extinguishers or 1-quart liquid extinguishers are recommended by manufacturers because rapidity and ease in handling make it possible to attack a fire quickly. It is said that a small extinguisher can be kept at each place where a fire hazard exists, whereas a large extinguisher must be kept where it is available for several such places. However, nothing is more discouraging to a fire fighter than to run out of extinguishing material just before a small fire is under control. Many excellent extinguishers have been condemned because too much was expected of them or an excessive amount of the extinguishing material was wasted. Considerable skill is needed when using small extinguishers to utilize the available extinguishing material effectively; to obtain this skill, practice performances should be held at least a few times every year.

Water barrels, from which water can be used without delay, are often more effective protection than a hose that has to be carried some distance and connected to a small-diameter pipe line. Precautions must be taken to prevent the barrels from being empty and the water from freezing.

Small-diameter garden hose may be useful as first-aid equipment, but too often such hose is considered as regular fire-fighting equipment and a false sense of security results.

Pails of sand or rock dust that can be used to smother a fire have prevented many small fires from spreading and are considered satisfactory protection of preliminary or first-aid nature.

CARE OF FIRE-FIGHTING EQUIPMENT

Every automobile owner knows that a car will not run without some attention; for example, storage batteries cannot be neglected indefinitely. Many mine operators forget that fire-fighting equipment should be considered as mechanical equipment. Whether the organization is large or small, someone must be responsible for the maintenance of the fire-fighting equipment if it is to be readily available when an emergency occurs.

Water valves in fire lines should be opened occasionally; deteriorated fire hose and connections that have been taken from fire-fighting lines should be replaced. The chemicals of some types of extinguishers require replacement at periodic intervals; other extinguishers require recharging with gas or new cartridges for efficient operation. Water must be added occasionally to water barrels, water must be prevented from freezing solid, and "borrowed" fire pails need to be returned to their proper places. Each piece of fire-fighting equipment should be stored in a well-marked, accessible place. Lack of maintenance or inspection of fire-fighting equipment was found in most small mines.

TRAINING OF EMPLOYEES

Men should be trained in the use of fire-fighting equipment and the more complicated the equipment, the more extensive the training required. Efficient use of a fire hose depends on training and practice. Some of the most disastrous surface fires have occurred at plants having excellent equipment that was used improperly. Sprinkler systems have been turned off by inexperienced men and main-line water valves have been closed when they should have been left open. Because locked gates at entrances to enclosed plants have been forgotten or the key misplaced, persons outside the plant responding to emergency calls were unable to enter. Fires that occur when untrained or new relief men are on duty may quickly become uncontrollable.

Underground fires have been discovered by men who became panic-stricken and searched in vain for fire-fighting equipment.

Even simple extinguishers must be used with some discretion.4/ Fires in ordinary combustible material, such as wood and paper, require the quenching and cooling effects of quantities of water to prevent rekindling of hot embers after the flame is extinguished. Oil and grease fires need only to be blanketed with gas or foam to extinguish the flame. Fires in electric equipment should be fought with a nonconducting extinguishing agent to prevent injury to the fire fighters. Some vaporizing liquid-type extinguishers release small amounts of toxic gas; this limits their use to well-ventilated places. To use an extinguisher effectively, employees must be instructed in the proper use of each type provided as well as in the type of fire it is designed to extinguish.

4/ Crosby, E. V., Fiske, H. A., and Forster, H. W., Handbook of Fire Protection: Nat. Fire Protec. Assoc., 1941, p. 700.

Where labor turn-over was high, it was found that little attention was given to the training of employees. The operator felt that any advantage gained by training the employees was lost because of changes in personnel. Records of small fires extinguished quickly by trained men at mines when labor turn-over is above normal show that instruction and practice drills are worth while.

The danger from the products of combustion in mines makes the warning of men in all sections of the mine of vital importance. If men are removed quickly from a mine as soon as a fire is discovered, the danger of suffocation is likely to be averted. Fire-fighting training for underground workmen should include the assembly of men at points of exit, such as shaft stations or tunnel connections. The crews trained for participation in fire fighting should be experienced in the use of self-contained oxygen-breathing apparatus. Operators of large mines recognize this and provide such apparatus; however, most operators of small mines rely on securing apparatus from someone else in an emergency.

RELATIONSHIP BETWEEN SURFACE AND UNDERGROUND FIRES

Surface and underground fires often are related intimately with regard to danger to men in the mine. At the average small mine, burning buildings close to the mine shafts or other mine entrances often make the hazard of suffocation of men underground as great as when a fire occurs in the mine. Efforts to prevent fires, both on the surface and underground, as well as utilization of means of preventing large quantities of fire gases from entering mine workings when fires do occur are responsible for the excellent records of many mines. There are many instances where underground fires have not been accompanied by fatalities because of careful thought and diligent work by the supervising officials for many years before the emergency arose.

CONCLUSION

Fire losses can be prevented by: (1) Precautionary measures before a fire starts; (2) removal of dangerous types of combustible material wherever possible; (3) control of ignition hazards; (4) providing extinguishing equipment; and (5) instruction of employees in fire-fighting procedure. Although all these measures are important, fortunately each is independent and by itself affords some measure of protection.

The records of 23 surface fires and 16 underground fires, some of which were serious, investigated by engineers of the Mineral Production Security Division during 1942, 1943, 1944, and 1945, at metal mines, offer substantial evidence that poor construction or lack of water does not excuse any further attempt to control fire losses; serious losses have been prevented with limited equipment by the prompt action of trained employees.